S. U. M. Hydroelectric Plant
McBride Avenue
Paterson, New Jersey
Passaic County

HAER No. NJ-16

HAER
NJ,
16-PAT,
21-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Department of the Interior
Washington, D.C. 20240

HAER
NJ,
16-PAT,
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HISTORIC AMERICAN ENGINEERING RECORD

S. U. M. HYDROELECTRIC PLANT

NJ-16

DATE:	1912-1914
LOCATION:	McBride Avenue Paterson, New Jersey
DESIGNED BY:	John H. Cook
OWNER:	City Of Paterson
SIGNIFICANCE:	The S. U. M. Hydroelectric Plant was constructed in 1912-1914 to meet the electrical power needs of the mill and factory owners and tenants in the Paterson area. It superseded the power canal system (HAER No. NJ-2), and is situated on a narrow neck of land on a bend in the Passaic River. The plant operated under a normal head of sixty-seven feet and incorporated four S. Morgan Smith horizontal shaft turbines. These were connected to 2400-volt, sixty-cycle generators of either 1720 hp. or of 1390 hp.
TRANSMITTED BY:	Monica E. Hawley, Historian, 1983

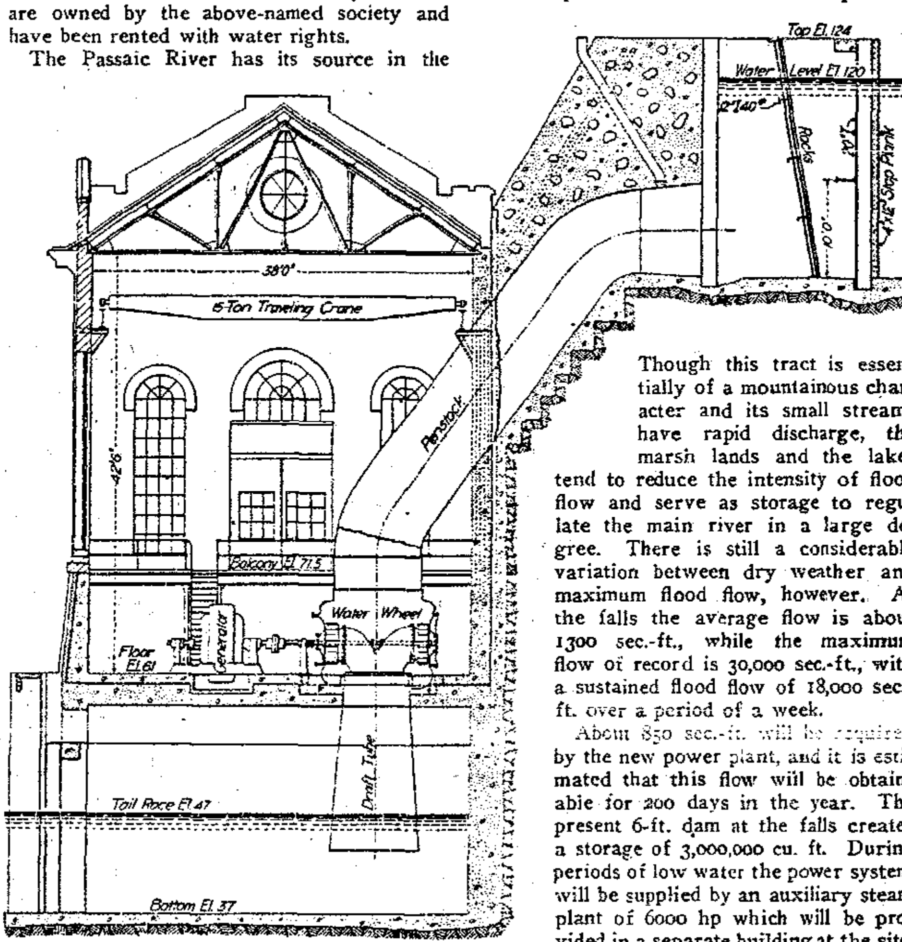
Hydroelectric Development Replacing Old Power Canal System

Short Cut-Off Around the Great Falls of the Passaic River in Paterson, N. J., Makes 6500 Horse-Power Available

By cutting through a long, narrow neck of rock for a distance of only about 100 ft., so as to connect the upper and middle arms of a Z bend in the Passaic River at points above and below the Great Falls in Paterson, N. J., a head of 67 ft. is now being developed to generate electric power which will replace old direct water drives in a group of mills ranged along a system of canals built a number of years ago to take advantage of the fall in the river bed at this site. The falls lie in the first or upper angle of the "Z"; a dam which formed a part of the original construction diverting water to the canals is situated about 150 ft. above them. Below the falls the right bank of the river, or that adjacent to the upper arm of the "Z," is a vertical cliff, presenting a very favorable location for the penstocks and power house against the face. The second turn in the river, opposite the power house site, affords a direct discharge from the tailrace into the lower channel. (The local topography, the old dam and canal, and the new power house are shown in the accompanying drawing.)

The Great Falls development, which is being carried out by the Society for Establishing Useful Manufactures, of Paterson, will furnish 4800 hp in the present installation, with a contemplated addition of 1700 hp. The water-power canals which it will eventually entirely replace were built by this company shortly after it was founded by Alexander Hamilton in 1791. These canals are located on three levels, following the contour of the land in general parallel to the river around its lower bend. Their intake is about 300 ft. back of the present dam, from which point the canal branches extend on levels about 20 ft. apart, each discharging into the one below, the last one leading to the river channel beyond the lower bend. The mills occupy practically all of the space between the upper and middle and the middle and lower canals. Many of them are owned by the above-named society and have been rented with water rights.

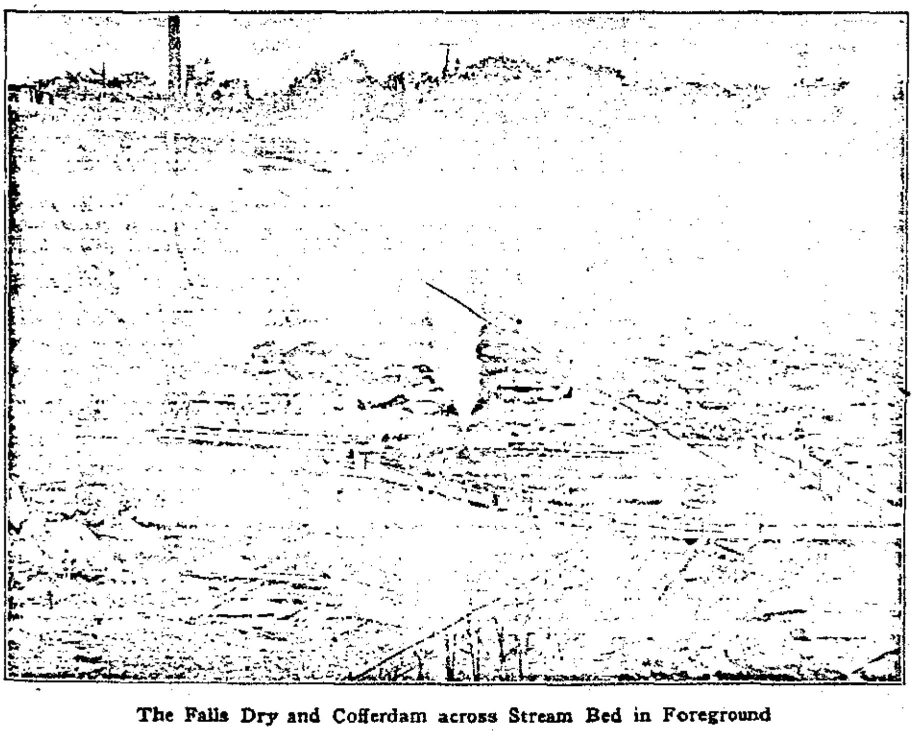
The Passaic River has its source in the mountains of eastern New Jersey and flows northeastward parallel to the Watchung Mountains, being fed at intervals by smaller rivers and mountain streams, many of which rise in small mountain lakes. Large areas of marsh land are tributary to, and are also traversed by, the Passaic River in several parts of its course. The entire watershed above the falls comprises an area of about 800 sq. miles.



Cross-Section of Power House

Though this tract is essentially of a mountainous character and its small streams have rapid discharge, the marsh lands and the lakes tend to reduce the intensity of flood flow and serve as storage to regulate the main river in a large degree. There is still a considerable variation between dry weather and maximum flood flow, however. At the falls the average flow is about 1300 sec.-ft., while the maximum flow of record is 30,000 sec.-ft., with a sustained flood flow of 18,000 sec.-ft. over a period of a week.

About 850 sec.-ft. will be required by the new power plant, and it is estimated that this flow will be obtainable for 200 days in the year. The present 6-ft. dam at the falls creates a storage of 3,000,000 cu. ft. During periods of low water the power system will be supplied by an auxiliary steam plant of 6000 hp which will be provided in a separate building at the site.



The Falls Dry and Cofferdam across Stream Bed in Foreground

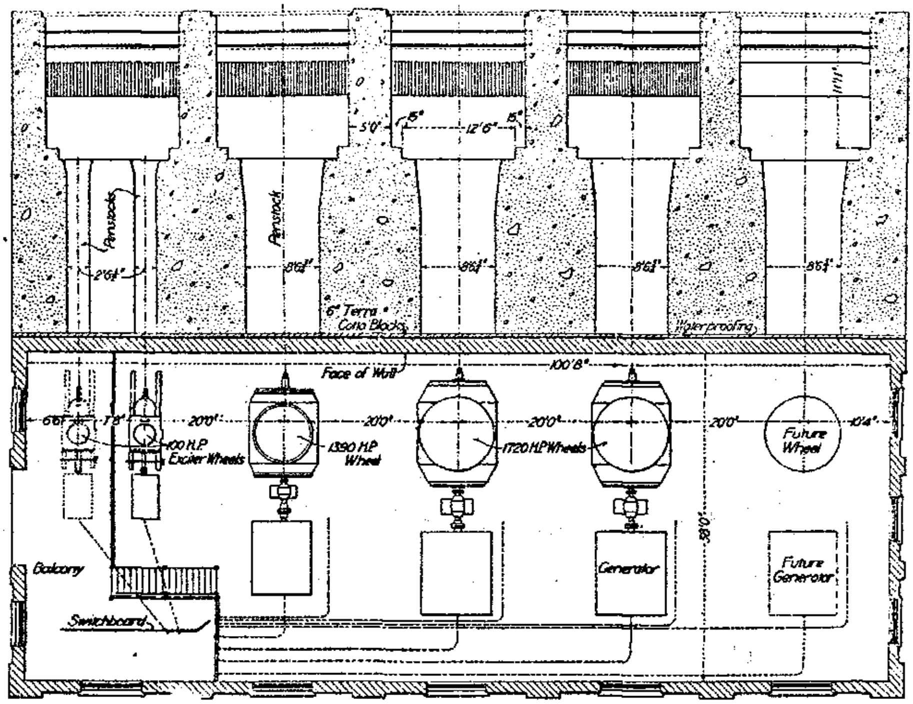
Work Included in Hydroelectric Development

Work on the present hydroelectric development embraces excavation for the intake across the neck of land between the river arms, the construction of the power house against the face of the cliff and the improvement of the lower river bed for about 1000 ft. below the power house. About 10 ft. in head is gained by the work in the lower river. The total difference in elevation between the top of the cliff and the original river bed at its foot is about 90 ft. and between the upper water level and the lower river bed 75 ft. A new 120-ft. channel is being excavated from the foot of the cliff, with a slope of 0.1 per 100 ft., occupying one side only of the natural river bed. This work involves also the removal of many large boulders which formerly littered the lower river and the construction of a reinforced concrete retaining and guide wall along the outside of the lower bend of the river, this being the side occupied by the new tailrace.

Details of the power house and related works and the arrangement of machines are shown in the accompanying cross-section and plan. Provision is made for four main units and two exciter units.

Details of Headworks

Water is led from the river just above the dam immediately through coarse trash racks



Plan of Power House, showing Arrangement of Machinery

into a forebay, which is 68 ft. wide at the racks, increasing to 90 ft. at the intakes, and is excavated to a depth 15 ft. below the water level. The outer trash racks are set with a slope of 6 to 1 against 4-ft. concrete piers, which divide the entrance to the forebay into three 20-ft. openings. A 12 x 12-in. rudder boom, 67 ft. long, protects the entrance from heavy drift. This boom is fixed to the abutment at the upstream end and is free at the downstream end, with a rudder attached at an angle of 45 deg. to keep it in place in the stream. The angle of the rudder may be changed in some degree by using different pinholes in the brace connecting its outer end to the boom.

The piers sustaining the trash racks are extended in the rear to support a 30-in. water main and a 12-in. high-pressure main which cross the head of the forebay. A concrete walkway is provided above these pipes.

In the concrete bulkhead at the end of the forebay there are five intake chambers, each 15 ft. wide, four of which lead to the main penstocks and the fifth to the two exciter penstocks. Across the entrance of each chamber there is a steel framework for stop planks, and immediately back of this are the fine racks.

The concrete bulkhead is of very heavy mass construction, extending over the edge of the cliff to join the back wall of the power house and embedding the heads of the penstocks. The main penstocks are 8½ ft. in diameter and the exciter penstocks 2½ ft. All are of steel.

POWER HOUSE AND EQUIPMENT

The power house comprises a main generator room, 38 ft. by 100 ft. 8 in., and a draft tube chamber beneath the main floor. There is a switchboard gallery extending across one end of the building above the exciters. A 15-ton traveling crane serves the main room.

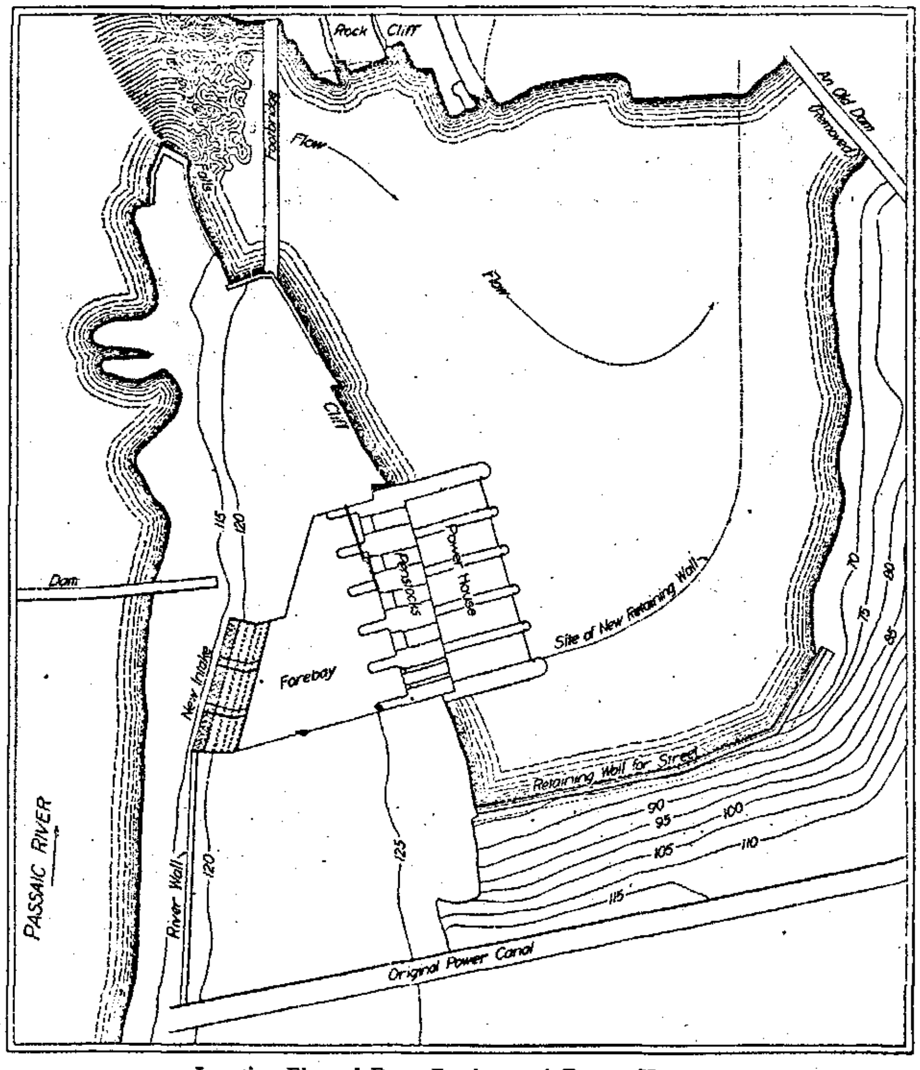
The turbines are of the S. Morgan Smith horizontal-shaft, double-runner type. They are connected to 2400-volt 60-cycle generators. Two of the main units in the center of the power house are 1720 hp each, and the third of the present installation is 1390 hp. Provision is made for an additional 1720-hp machine at the opposite end of the room. The exciter units are 100 hp each.

The main turbine draft tubes are vertical, 17 ft. long, 6 ft. in diameter at the tops and 8 ft. at the lower ends. There is a 10-ft. depth of water in the draft tube chamber. A framework for stop planks is provided in the outer wall of the draft tube chamber at the head of the tailrace.

PLAN OF CONDUCTING CONSTRUCTION

In the construction of the plant it was necessary to excavate the forebay behind a cofferdam protecting it from the upper river and the clear and improve the lower river bed at the power house and tailrace sites behind a second cofferdam, protecting this work from the lower pool. Simultaneously the entire river channel below the work was cleared of its large boulders during periods of low water. The upper cofferdam was built on rock bottom in about 15 ft. of water and was puddled between two rows of tongue-and-groove sheeting. The lower cofferdam was of similar construction, except that a bottom of boulders and loose material over about half its length, or 100 ft., required the use of an outer cut-off curtain of 6-in. United States sheet steel piling.

A steam pumping plant was installed over a sump near the middle of the lower cofferdam wall with an equipment of three centrifugal pumps of 4 and 8 in. in diameter. To drain the upper cofferdam, however, it was found practicable to employ a siphon, pumping being limited only to high-water periods and emergencies. An 8-in. siphon line was led from the cofferdam around the falls of the river and into the lower river bed near the lower cofferdam. It was equipped with a gate on the lower end and connected at the top with a 2-in. water ...



Location Plan of Dam, Forebay and Power House for priming. Following the successful operation of this siphon, it was extended to pass the sump of the lower cofferdam, and a connection was made to the draft pipe from the pump well, with a reduced nozzle section of pipe in the main line immediately above the junction, thus forming an ejector, in which the flow from the upper river was utilized to drain the lower cofferdam.

Central Construction Plant

Excavation behind the two cofferdams was conducted from a centralized construction plant situated on the edge of the bluff just beside the forebay excavation. Three derricks, one situated in the lower excavation, one commanding the upper excavation and one on the edge of the bluff between, served the entire area. All of the rock in these excavations was handled at the upper level, some of it being piled for plums in the mass concrete of the bulkhead and power house, some loaded into Koppel dump cars on a portable track at the upper level for removal to waste piles and the remainder passed to the hopper of a rock crusher in the concrete mixing plant which formed a part of the central plant.

Clearing boulders outside the lower cofferdam in the lower river was done with the aid of a Lidgerwood cableway extending along the new channel to waste piles on shore. Additional derricks on the bluffs of the lower river also assisted in this work.

Rock for concrete work which is not yet completed is passed from the receiving platform of the concrete plant into a 10 x 12-in. Farrell crusher, which feeds directly into a bucket elevator leading to the material bins over the mixer. Sand is brought to the work from a distance. The mixing plant is equipped with a 1-yd. Smith mixer, which discharges in the range of the middle derrick to 1-yd. Stuebner bottom-dump buckets, in which concrete is distributed to place. Large stones are placed in all mass concrete, one-man size being used in small walls and ¾-yd. pieces in heavy masonry.

All of the machinery in the central power plant is supplied from a single boiler and engine house. Air for operating the drills in excavation has been supplied from compressors in the power plant of one of the mills.

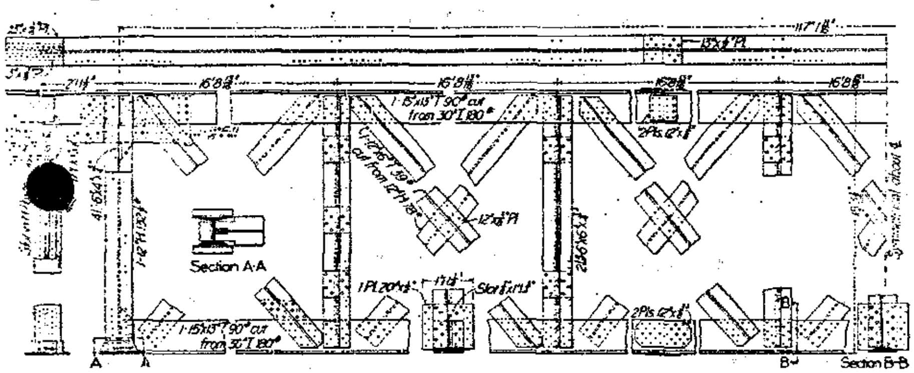
The construction of the Great Falls power development is being carried out under the direction of Mr. John H. Cook, hydraulic engineer of the Society for Establishing Useful Manufactures, with Mr. H. E. Abbott, assistant engineer, in charge of construction.

The Flooding of a Sewer Tunnel of the new Passaic Valley system, now under construction in New Jersey, occurred on Feb. 17. Eight of the workers are reported to have

Bridge Trusses with Uniform T-Shape Members

The boroughs of Rochester and Monaca, Beaver County, Pennsylvania, are connected by a highway bridge, 2200 ft. long, carrying a 22-ft. roadway and 6-ft. sidewalk across the Ohio River. The structure was designed for highway and light street car traffic and was completed and opened for service in January, 1896. The trusses, towers and columns were made of Bessemer steel.

A 117-ft. approach span over the tracks of the Fort Wayne Railroad at Rochester was subject to the locomotive blast and sulphur fumes from trains passing under it and was replaced in 1911 by a new span with through-riveted Pratt trusses having special features in the proportioning and detailing of their members. In this span the designer, Mr. Edwin K. Morse, of Pittsburgh, developed some features that he had long intended to apply to a short span in the interest of increased simplicity, economy and efficiency. All of the web members are heavy, and are of the same cross section throughout; thus, being adequate for the stresses at the ends of the span, provide at the center an excess mass to resist vibration. The extra weight thus involved is largely offset by the saving effected by the simplicity and economy of design.



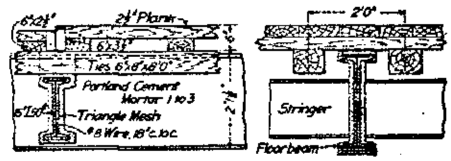
Half Elevation of Truss, showing Old Riveting

Another important and unusual feature was the use of single, rolled, T-shape pieces of large dimensions for all of the chords and diagonal members of the trusses. These up to a maximum of 15 in. deep were secured by cutting on the center line through the webs of Bethlehem H-beams and I-beams. They were considered very satisfactory for the top and bottom chord sections, where they afforded sufficient space for direct web-member connections without gusset plates. It was feared that when the shapes were split the initial stresses would cause the pieces to buckle or warp, but this proved not to be the case, and no evidence of unbalanced internal stress was detected.

The estimated weight of the bridge with truss members of uniform section having wide web and flanges, eliminating connection plates, was no greater than that estimated for trusses with members of variable cross-section and ordinary connection details. The design adopted gives thicker metal throughout and consequently reduces the effect of deterioration by rust, requires less maintenance, and is considered to present a better appearance than ordinary trusses. Furthermore, the cost per pound of fabrication was stated to be certainly not greater than that for corresponding built-up members.

Each panel of the truss has a main and counter diagonal, each made of half a 12-in.,

of the top and bottom chord webs and riveted together through filler plates at their intersections. The intermediate verticals have star-shape cross-sections, each made of two 6 x 6 x ¾-in. angles, with the longitudinal flanges riveted to the opposite sides of the chord web and to tie plates at both ends. The top and bottom chords are made of halves of



Floor Details of Bridge

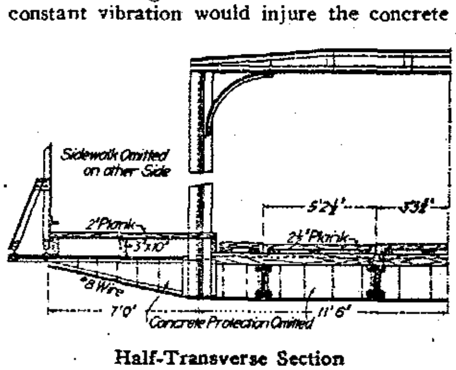
30-ft., 180-lb. I-beams spliced near the center of the span with a pair of web cover plates and one flange cover plate. The end vertical posts are H-beams with hitch-angle connections between their webs and those of the top and bottom chords.

The top-chord transverse struts are made of two pairs of angles back to back, connected by vertical tie-plates, and the panels between them are X-braced with single angles having connection plates field-riveted to the horizontal flanges of the top chords. The panels between the floorbeams are X-braced by pairs of 3 x 3-in. angles, riveted back to back.

The floorbeams are 24-in., 100-lb. I-beams, with hitch-angle connections to the vertical posts, and are extended at both ends by sidewalk brackets with similar connections. The brackets have solid web plates and pairs of horizontal and inclined top and bottom flange angles, the former extended beyond the ends of the bracket to receive the ends of inclined braces for the handrail posts. There are four lines of 15-in., 50-lb. I-beam stringers.

The steelwork below floor level was protected by a concrete casing reinforced and anchored by triangle mesh weighing 37 lb. per square. Special care was taken to cover the tops of the stringers with Portland cement mortar 1½ in. thick, on which, when it was one week old, were laid the ties.

During construction traffic was maintained on one longitudinal half of the bridge floor while the other half was being concreted, and notwithstanding the contractor's fear that the constant vibration would injure the concrete



Half-Transverse Section

no damage to it was observed after two years' service except slight spalling from the sidewalk brackets. One week after the first half of the floor had been concreted traffic was transferred to it, and the other half was concreted and no crumbling or breaking of the concrete has yet been observed under the bearings of the ties. Members inclosed in concrete were not painted; other members were painted one shop coat of red lead and two field coats of Puritan graphite. The bridge was fabricated by the Penn Bridge Company, Beaver